DEPARTMENT OF COMMERCE

UNITED STATES BUREAU OF MINES
SCOTT TURNER, DIRECTOR

INFORMATION CIRCULAR

RADIUM IN MEDICAL USE IN THE UNITED STATES

BY

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DEPARTMENT OF COMMERCE - BUREAU OF MINES

RADIUM IN MEDICAL USE IN THE UNITED STATES[1]

By R. R. Sayers[2]

Radioactivity, the property of radium that led to its isolation more than 30 years ago, is the characteristic that makes it of value in the treatment of disease. Tyler[3] gives the following brief history of the investigation:

> The way to the discovery of radium was opened in 1895 by Röntgen, who found that the glow from a Crooke's tube contained penetrating rays, which he called X rays. Prof. Henri Bequerel, while investigating the effect of various phosphorescent substances, found that uranium salts produced photographic impressions even when enveloped with opaque substances. To Marie Sklovouski, a young Polish student, who later became Madame Curie, Professor Bacquerel delegated the task of learning how and why uranium possessed power to emit these peculiar rays, which he had proved to be electrical in character. Madam Curie, examining by electrical methods the radioactivity of a large number of minerals containing uranium and thorium, discovered that some specimens of pitchblende had about four times the activity of the metal uranium; that chalcolite, the crystallized phosphate of copper and uranium, was twice as active as uranium; that autunite, a phosphate of calcium and uranium, was quite as active as the same weight of pure uranium. In order to check these discoveries, she prepared chalcolite artificially, starting with pure products, but found that this artificial chalcolite had only the activity represented by its composition, or, roughly, 40 per cent of the activity of uranium. This led to the conclusion that there was some element or substance in the residue from uranium minerals that possesses a high degree of activity. After an exhaustive chemical investigation of pitchblende from Joachimsthal, she found that this mineral contained not only uranium but also another radioactive substance, to which she gave the name of polonium, in honor of her native land. Later in 1898, Monsieur and Madame Curie found still another element, which, when brought to a state of concentration, was several million times as active as uranium, and to this was given the name of radium. Debierne afterwards found a fifth radioactive substance, actinium; and in 1906 Boltwood isolated the metal ionium. Strictly pure radium chloride was first produced in 1902.

The first radium was produced commercially from the uranium residues obtained from the mines of Joachimsthal, Bohemia. Tyler calls to attention that, as the ores were a government monopoly, search was begun at once for sources in other parts of the world. As a result, radium-containing ores have been found in about 10 countries.

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1 - The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6667."
Presented before the meeting of American Society of Radiologists, St. Louis, December 1, 1931.

2 - Chief surgeon, U. S. Bureau of Mines; surgeon, U. S. Public Health Service

3 - Tyler, Paul M., Radium: Inf. Cir. 6312, Bureau of Mines, 1930, 55 pp.

The interest of the Bureau of Mines in the efficient recovery of radium extends back to about 1912. Under an agreement with the National Radium Institute[4] the bureau built and, in June, 1914, began the operation of a radium recovery plant at Denver, Colo. By the time the work ceased in January, 1917, 8.5 grams of radium had been produced. The methods devised by this investigation reduced the cost of recovering radium to about one-third of the then current prices. F. L. Hess, principal mineral technologist of the Bureau of Mines, states that at present only two countries are producing significant quantities of radium - the Belgian Congo at Chinkolobwe, Katanga, and Czechoslovakia at Jachymov (formerly St. Joachimsthal). In 1922 there was an important development in the radium industry by the opening in that year of the radium works of the Société Metallurgique de Hoboken at Oolen, in Belgium, which soon acquired a monopolistic position. The material treated in these works was obtained from the Belgian Congo through the Union Minière du Haut Katanga. In the concessions of this company, which is primarily copper-producing, radium-bearing ore was discovered at Luiswishi in 1913 and at Chinkolobwe in 1915. ********** The present productive capacity of the Oolen works is about 6 grams of radium monthly. At present, the price fluctuates between 60 and 70 dollars per milligram (pounds 12 10s. to pounds 15), or is in the region of 270 marks.[6] These two countries now produce annually about 60 grams and 3.5 grams, respectively. Besides these, seven other countries have radium deposits which, in order of size of the known deposits, are about as follows: United States, Canada, Russia, Portugal, Madagascar, England, and Australia. It is possible that the position of the first-named countries may be reversed before another year has passed. The deposits discovered in 1930 on the east side of Great Bear Lake, District of Mackenzie, Canada, are said to be the richest and possibly the largest yet found.[7] From prospecting operations during 1931, 20 tons of pitchblende were obtained and shipped. The extractions that have been made from batches of this ore have been well over 90 per cent. The 20 tons is said to contain at least $100,000 worth of radium at present prices.

During the past few years, the amount of radium now used for medical purposes has been much discussed. In Great Britain plans for distributing and supervising the supply of radium for treatment of disease have been completed and put into effect. The first annual report[8] states that the National Radium Trust has as its chief duties: To take charge of funds raised by public subscription and voted by Parliament for the provision of radium and to arrange for the purchase of radium. The Radium Commission has the duty of making the arrangement for the proper custody, equitable distribution, and full use of the radium purchased by the Radium Trust. The Radium Commission is composed of 10 members and a chairman. The trust appoints the chairman. The Minister of Health, the Secretary of State for Scotland, the Medical Research Council, and the Department of Scientific and Industrial Research severally appoint one of the members. The remaining six members are selected by the trust from a panel of not less than 12 persons having special knowledge and experience in the application of radium in the treatment of the sick. Up to August, 1930, the National Radium Trust had ordered 18.5 grams of radium. Of this amount some 18 grams had been provisionally allocated to national centers; only 14 grams had been received from the radium manufacturers, and not more than 8 grams had been actually delivered to the centers. In France[9] the government has established 15 radium centers in various parts of the country, and allocated to them 31.5 grams of radium (in addition to about 20 grams believed to be privately owned). In Sweden[10] the use of radium is highly organized under Government auspices. A strong movement was started in 1929 to acquire a larger supply of radium in England, where a governmental committee recommended that 24 grams be acquired in addition to about 25 grams then available in the British Isles. In Germany[11] -

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[4] - The National Radium Institute (Inc.), was a corporation organized and existing under and by virtue of the laws of the State of Delaware for the study of the best methods of producing uranium, vanadium, and radium.

[5] - This statement is contained in a chapter prepared for publication in Spurr and Wormser's Marketing of Metals and Minerals.

[6] - Canadian Mining Journal, The Belgian Radium Industry: June, 1932, pp. 255-256

[7] - Goodwin, W. M., Mines Branch Radium Plant: Canadian Min. Jour., June, 1932, pp. 253-255.

[8] - National Radium Trust and Radium Commission First Annual Reports, 1929-1930: London, 1930, 74 pp.

[9] - See reference 3

> The federal commission for the control of cancer summoned experts recently to discuss the question of the purchase and distribution of radioactive substances such as radium and mesothorium. As a result, the Deutsches Zentralkomittee zur Erforschung und Bekämpfung der Krebskrankheit and the Reichausschuss für Krebsbekämpfung agreed on certain criteria, which are set forth in a communication by Professor Friedrich: The purchase of radioactive substances should be considered only by such institutions as have an experienced radiologist for the therapeutic application of such substances. The use of small quantities of radioactive substance for the local treatment of carcinomas is the method indicated bythe present status of medical knowledge, whereas the treatment a distance with heavy doses of several grams is a method concerning which no definitive opinion can be given as yet. Supplies of radioactive substances should be available in all university clinics and large hospitals, the amount ranging from 200 to 500 milligrams, according to the population of the area for which provision is made. Some centers should have an additional amount in order that they may serve also as research centers. Such central institutes should have an average of 50 milligrams of radioactive substance for each bed designed solely for patients to be irradiated. A central institute should have not less than 20 beds set apart for the use of cancer patients to be irradiated with radioactive substances, which presupposes accordingly the possession of 1,000 milligrams of radioactive substance. Since experience has shown that the biologic effects of the rays emanating from radium and mesothorium are of equal value, in the purchase of supplies the choice as between radium or mesothorium should depend exclusively on economic and practical considerations. The legal regulation of the application of radioactive substances for therapeutic purposes is a problem of the near future.

In the United States, from the time that American radium factories made the first production of radium salts in 1913 to the last recorded output in 1926, they isolated about 203.3 grams of radium. Besides this production the following imports of radium in salts are shown by the customs records. It is thought that at least 3 grams were imported previous to 1923, at which time Belgian radium began to arrive in this country. Production and imports are shown in the following table:

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[10] - See reference 3.

[11] - Journal of the American Medical Association, The Purchase and Distribution of Radioactive Substances: Foreign Letters, Berlin, vol. 97, No. 14, October 3, 1931, p. 1016.

Original from THE OHIO STATE UNIVERSITY

Year	Radium produced in the United States, grams	Radium imported into the United States, grams
1913	2.1	-
1914	9.6	-
1915	4.71	-
1916	8.17	-
1917	13.83	3.00 (estimated)
1918	22.79	-
1919	28.648	-
1920	32.539	-
1921	35.693	-
1922	24.189	-
1923	12.212	8.75
1924	3.365	8.1
1925	2.952	9.27
1926	1.725	10.97
1927	none	7.26
1928	none	10.97
1929	none	10.69
1930	none	16.86
Total	202.523	85.87

The total production and imports into this country to the end of 1930 have been in the neighborhood of 288.4 grams. It is probable that since 1916, including use during the Great War, not more than an average of 2 grams per year has been used in luminous materials, a total of not more than 30 grams. What exports have amounted to is unknown, but they have probably not exceeded 20 grams, so that, making no allowance for broken tubes and other losses there would appear to be still in this country 238 grams of radium. This is very much more than can be accounted for from holdings, and there may have been much larger exports than have been recorded.

The amount of radium in the United States now used for medical purposes has been variously estimated at 50 to well over 200 grams. The following statement was published in the Journal of the American Medical Association:[12]

> According to figures supplied by the American Society for the Conrol of Cancer, which are recognized to be only relatively complete, the total amount of radium owned in quantities of 75 milligrams and over in the United States is 85,228 milligrams. The hospitals owning 75 milligrams and over number 135. The 135 hospitals own 68,033 milligrams. The individuals owning 75 milligrams and over total 47, with a total of 6,945 milligrams.

The United States Bureau of Mines recently sent out to all the hospitals listed in the 1931 Directory of the American Medical Association the following letter and questionnaire, A and B.

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[12] - Journal of the American Medical Association, Radium Owned by Hospitals and Physicians: Vol. 96, No. 24, June 13, 1931, p. 2057.

UNITED STATES
DEPARTMENT OF COMMERCE
BUREAU OF MINES
WASHINGTON

The Bureau of Mines is asked repeatedly as to the need for additional radium in the United States. The question naturally arises as to how much is now available, the number of people receiving treatment, and the total number of treatments needed.

In order to more accurately supply this information, the inclosed questionnaire is being sent to the principal hospitals in the United States. I would very much appreciate it if you would have this form filled out as completely as possible and returned at once in the inclosed franked envelope.

Yours sincerely,

R. R. SAYERS,
Chief Surgeon, U.S.B. of M.
Surgeon, U.S.P.H.S.

Inclosures

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DEPARTMENT OF COMMERCE

UNITED STATES BUREAU OF MINES
SCOTT TURNER, DIRECTOR
WASHINGTON

CONFIDENTIAL
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USE ONLY

RADIUM - FOR MEDICAL USE

1. How much radium (element) have you on hand .... Grams .... Milligrams

2. Please show below quantity of radium in each salt:

Salt	Grams	Milligrams	Salt	Grams	Milligrams
Bromide......	....	....	Carbonate......	....	....
Sulphate....	....	....	Other(Please specify)......	....	....
Chloride....	....	....			

3. Date when acquired ....

4. Please show below quantity of radium in each form:

Form	Grams	Milligrams
Applicators..	....	....
Needles..	....	....
Tubes..	....	....
Solution..	....	....

5. Number of patients treated annually ....

6. Total number of treatments ....

7. If you do not have radium, how is radium treatment obtained for patients in your hospital or in your vicinity who need such treatment? ....
....

8. What is the usual price paid per milligram hour by your hospital or by individuals to institutions or persons furnishing radium treatment? ....
....

9. Are these arrangements satisfactory to your institution? ....

10. How much more radium could you use to advantage? ....
(This question is intended only to give the United States Bureau of Mines an idea of the country's need for more radium)

11. Do you know of physicians outside of hospital having radium in your city? If so, please give names on reverse of this sheet.

....
(Please sign here)
(Official title)....................

(B)

Original from THE OHIO STATE UNIVERSITY

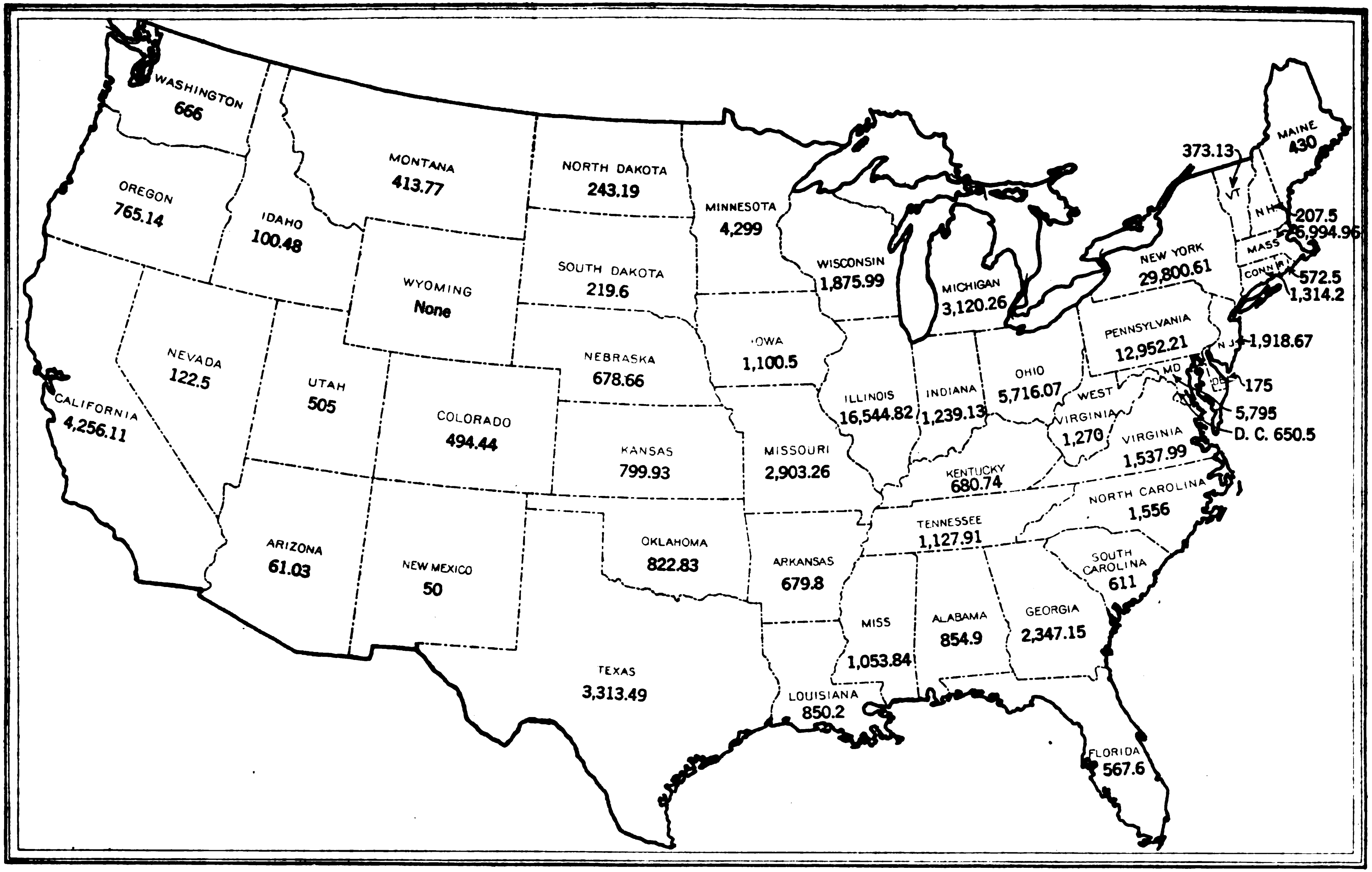

Figure 1 — Distribution of radium for medical use in the United States, milligrams

To date 287 hospitals and clinics have reported that they have a total of 85,800.26 milligrams of radium, and 128 of the 287 each had 75 milligrams or more; 414 physicians have reported that they have 33,286.93 milligrams and 171 of the 414 each had 75 milligrams or more; 9 laboratories and companies have reported that they have 5,545.42 milligrams and 5 of the 9 each had 75 milligrams or more. New York, as would be expected, had the largest amount - 29,800.61 milligrams; Pennsylvania had the next largest amount - 12,902.21 milligrams. Five States reported no radium in hospitals, and according to the reports received, no radium is owned in one State. (See fig. 1.)

All of the reports did not designate the kind of salt in which the radium was held. Those reporting, however, gave the following quantities:

	Milligrams
Bromide	24,676.44
Sulphate	49,939.23
Chloride	17,047.11
Carbonate	169.01
Other	1,119.64

The quantity of radium in each form, as shown by the reports, is as follows:

	Milligrams
Applicators	4,186.60
Needles	42,369.63
Tubes	35,223.79
Solution	26,027.65

From the reports it is estimated that the number of patients treated annually with radium is approximately 80,000. The accompanying map shows the distribution of radium for medical use by States. Seven hundred and ten individuals, companies, and hospitals, owning 124.7 grams of radium, estimate that they need 117.4 grams more.

It has been suggested that the amount needed might be estimated from the number of persons who could be benefitted by radium treatment. As any statistics for such an estimate are very limited, it seems best to consider only malignant new growths and to neglect the 25 or 30 other conditions that, at least in selected cases, are benefitted by radium.

In 1900 when the registration area was first formed, the crude death rate from cancer was 63 per 100,000 population. In 1920 it was 83.4, and in 1929 (the latest available figures) it was 96.1, an increase over the crude death rate of 1900 of nearly 52½ per cent. In 1929 the total number of deaths from cancer was 111,569. This makes cancer the second most important cause of death. Heart disease alone with 245,000 deaths claimed a greater number of victims. One of the most striking increases in the death rate has been in the so-called external forms of cancer, such as cancer of the breast and cancer of the mouth, in which, because of the superficial position, errors in diagnosis are low as compared with the possibility for error in deep-seated cancer such as that of the stomach or other internal organs.[13] Hess, using these cancer mortality statistics as a basis, estimates that "at least 10 times as much radium could be used advantageously as seems to be held in this country at present."

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[13] - The above figures are quoted from Health News, issued by the United States Public Health Service on October 13, 1931.

SUMMARY

Radium was first produced commercially from residues of uranium from the mines of Joachimsthal, Bohemia. Radium-producing ores have been found in about 10 countries.

The United States Bureau of Mines devised methods of recovering radium which greatly reduced the cost. The plant operated by the Bureau of Mines from June, 1914, to January, 1917, produced about 8½ grams of radium.

Up to 1926, 202½ grams of radium have been produced in the United States;none has been produced since that date. 85.87 grams have been imported into the United States, chiefly since 1923.

It is estimated that 2 grams per year, or a total of 30 grams, have been used for luminous materials.

In about 83 per cent return on over 6,600 hospitals and clinics in the United States, 287 report having 85.8 grams of radium; 128 hospitals and clinics each have 75 milligrams or more; 414 physicians report having 33,286.93 milligrams, and 171 physicians each have 75 milligrams or more; 9 laboratories and companies report having 5,545.42 milligrams, 5 of which each have 75 milligrams or more. New York State reported 29,800.61 milligrams. No radium was reported from one State and no radium was reported in hospitals from five States. Seven hundred and ten individuals, companies, and hospitals, owning 124.7 grams of radium, estimate that they need 117.4 grams more. From the reports, it is estimated that approximately 80,000 patients are treated annually with radium.